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EUROPEAN SCIENTIFIC NOTES NUMBER 8-17, (U)  
SEP 54 E EPREMIAN  
ESN-8-17

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12 12p.

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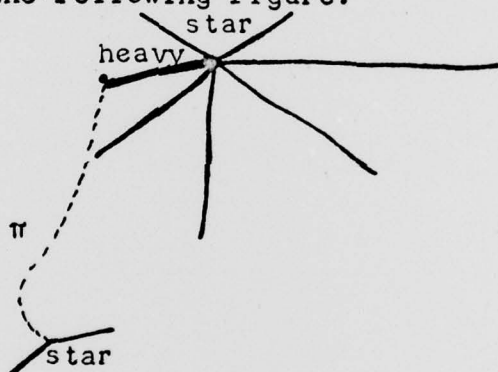
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RECENT RESULTS FROM NUCLEAR EMULSION WORK AT BRISTOL

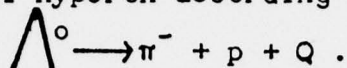
Among the recent research results obtained by the cosmic ray group under the direction of Prof. C. F. Powell at the H. H. Wills Physical Laboratory, Bristol, is the finding of an excited heavy nuclear fragment of atomic number  $z \geq 3$  which decays into two particles, namely a negative  $\pi$  meson and a nuclear recoil fragment. The observations are shown schematically in the following figure.



Although disintegration of heavier nuclear fragments has been observed before, this is the first case in which the disintegration is so simple, yielding a  $\pi$  meson and a recoil fragment. The length of the heavy track is only 30 microns and it makes a  $30^\circ$  angle of dip with the surface of the emulsion so that the measurements on the atomic number of the particle are difficult. All that can be said is that  $z \geq 3$  although it is most probably 7 or 8. The energy of the  $\pi^-$  meson is 33.5 Mev and it produces a star at the end of its track. Since the  $Q$  of the  $\Lambda^0$  is 37 Mev, one can conclude that the binding energy of the  $\Lambda^0$  in the nuclear fragment is  $< 11$  Mev. If there are any gamma rays emitted in the disintegration, this limit on the binding energy would be reduced. This work has been done by Doctors M. W. Friedlander, N.G.K. Menon, and others.



These same investigators have also made measurements on a group of two-prong stars observed in stripped photographic emulsions. In each event the outgoing particles are identified as a proton and a negative  $\pi$  meson, and the assumption is made that these events represent the decay in flight of a neutral hyperon according to the scheme



Under these assumptions they obtain a weighted mean  $Q$  value of  $36.92 \pm 0.22$  Mev. This yields a mass for the  $\Lambda^0$  particle of  $2181 \pm 1 m_e$ .

Another interesting event which has been examined by these same investigators is one which can apparently only be interpreted satisfactorily as a K meson-electron decay. In this event the K meson is observed to come to rest and emit a lightly ionizing particle. Mass measurements on the K meson by photometric and range method yield a value of  $1050 \pm 100 m_e$ . The secondary, however, has a  $p\beta$  of 90 Mev and a ratio of grain density to plateau grain density of 1.0. The point corresponding to this combination of values is located at a point 2.5 $\sigma$  from the linear extrapolation from the  $\mu$  meson curve on the  $g$  versus  $p\beta$  diagram. In addition, this lightly ionizing particle, after a considerable distance, apparently undergoes an angular deviation of some  $15^\circ$  after which it can be identified as a relatively slow electron. The most reasonable assumption which is compatible with these data is that the secondary particle is a fast electron which later undergoes a Bremstrahlung deviation where it loses most of its energy. The probability that this is the decay in flight of a  $\mu$  meson would be  $4 \times 10^{-4}$ ; in addition, this assumption would contradict the measurements on the  $p\beta$  and ionization. It is probable that this method of decay of the K meson is quite infrequent although it might have a probability as high as 10 per cent and this would still be consistent with present observation.

Some of the work reported in a previous issue, ESN 8, 134 (1954), has been continued. The work by Waddington, Yasin, and others on slow particles emitted from stars, has been extended to include 3500 particles. These particles all have a  $\beta < 0.5$  corresponding to  $g^*$  greater than twice minimum (corresponding to a proton range less than 10 cm). Ten K mesons are included, 9 of which decay at rest and one decays in flight. The energy of the K mesons observed so far are 23, 94, 59, 24, 92, 59, and 90 Mev. It is interesting that two hyperons have also been observed and that in each case they arise in the same star as that in which a K meson

originated. This may be considered to be evidence for reaction of the type  $\pi + N \longrightarrow K + Y$ . The total time of flight of the K mesons is of the order of  $10^{-9}$  sec and, as mentioned previously, one decay in a flight is observed.

The work of Doctors D. W. Perkins and P. Fowler on the mass measurements of fast particles originating in stars has also been continued with the result that 120 particles can be identified as protons and 4 have a mass about  $1000 m_e$ . Also observed were one hyperon, two particles each of which gives an indicated mass of 2900, and also one tau meson which yields a mass value of  $940 \pm 50 m_e$ . All the mass values are derived from measurements on the mean scattering angle and the grain density. There are now 16 particles in the puzzling group at  $1490 m_e$  and this group seems to be definitely resolved from the proton group at  $1850 m_e$ . Most recently the work has emphasized checks on the method, in particular the possibility of distortion in the emulsion has been checked by measurements on 6  $\pi$  mesons each yielding a very good fit on the curve to be expected from the proton results. The excellent value for the mass of the identified tau meson is also a good confirmation of the validity of the method. It is felt that the piling up of additional statistics would not be of great significance in this problem but that it is rather more important to change the conditions of the measurements. With this in view, Perkins and Fowler are next going to expose large stacks of stripped emulsions with the expectation that they will be able to stop some of these particles and so could use the range as well as the blob density and scattering measurements in the determination of mass. These stacks will consist of 40 emulsions 600 microns thick and of area  $10'' \times 12''$ . In these plates they hope, therefore, to get 20 cm of path. It is not expected that anything startling will occur at the end of the range of these particles since this would otherwise have been observed previously.

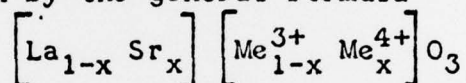
The first of these stacks was successfully exposed on 7 July by a high altitude balloon over Britain which evoked interested comments on the BBC television and in the press.

#### SEMICONDUCTOR CONFERENCE

An International Conference on Semiconductors, organized by the Netherlands Physical Society and supported by the International Union of Pure and Applied Physics and UNESCO, was held in Amsterdam, 29 June to 3 July. This second international conference in this field emphasized the

rapid expansion of interest in this branch of physics over the past few years. As compared to the previous meeting at the University of Reading, England, in July 1950, the present conference was larger by a factor of two and a half in attendance and in the number of papers presented.

The meeting was characterized not only by a wealth of material presented but by its variety. The greatest amount of experimental work continues to be done on the covalent crystalline substances, germanium and silicon, so that now the knowledge of these materials is becoming decisive. Considerable interest continues in the partially ionic crystalline materials, lead sulphide, lead selenide and lead telluride, partly because of their possibilities as receivers for infrared spectroscopy. A growing interest in the various intermetallic compounds, besides the group III - group V type, was evident and the almost limitless possibilities of ternary and quaternary compounds was emphasized. The interesting work at the Philips Eindhoven Laboratories with the oxidic system of perovskite crystal structure given by the general formula



has been extended to include Ti, Cr, Mn, Fe, and Co as the metallic atom Me. One of the general results is that the following sequence of decreasing preference for the tetravalent state is found, Ti - Mn - Cr - Fe.

At the General Electric Company, Ltd., a number of new semiconducting compounds of the substituted diamond type structure (e.g. chalcopyrite— $\text{CuFeS}_2$ ) are being investigated for rectifier or transistor applications. For example, good n-type high back voltage rectifying contacts have been made on  $\text{CuInSe}_2$  and  $\text{AgInSe}_2$ . Although the carrier mobilities are rather low yet, it is probable that purification will improve this considerably. Even organic substances are being investigated, as for example the work at the Services Electronics Research Laboratory, Baldock, England, on solid solutions of certain condensed aromatic hydrocarbons in anthracene and pyrene.

It was evident that most of the work with microwave techniques is still being done in the United States. The European laboratories are determining electrical effects mostly with measurements on magneto resistance, Hall effect, conductivity, and photoconductivity. Of the relatively new experimental results reported, mention should be made of recombination radiation measurements in germanium



by Dr. P. Algrain at the Ecole Normale Supérieure in Paris, of interesting exceptionally large electronic heat conductivity effects by Dr. G. Busch of the Physikalisches Institut der Eidgenössischen Technischen Hochschule, Zurich, and of minority carrier extraction effects discovered by Dr. A. F. Gibson of the Radar Research Establishment, England. Carrier extraction is found to be some twenty times more effective in modulating the carrier concentration than carrier injection.

Much progress has been made in the theoretical development of band structures, especially for the cubic crystals (diamond, Ge, Si), and the introduction of warped or non-spheroidal energy surfaces by Prof. C. Kittel of Berkeley was of considerable interest. Dr. L. Pincherle of R.R.E. reported considerable progress in this direction for the more difficult case of polyatomic crystals (PbS) using the cellular approximation and variational techniques for connecting the cells.

A more complete account of this Conference is being prepared as a technical report.

#### PHYSICAL CHEMISTRY RESEARCH AT THE UNIVERSITY OF LEEDS

Following the retirement of Prof. F. Challenger and the appointment of Dr. B. Lythgoe as his successor, there are now three professors of chemistry at the University of Leeds heading independent departments. F. S. Dainton is Professor of Physical Chemistry, E. G. Cox of Inorganic Chemistry, and Lythgoe of Organic Chemistry (cf. ESN 5, 80 (1951)).

The main research activities in the Physical Chemistry Department include work on radiation chemistry, electron transfer reactions and the kinetics and thermodynamics of polymerization reactions under Prof. Dainton and Doctors E. Collinson, T. J. Hardwick and K. J. Ivin. The polymerization thermodynamics program includes some interesting collaborative work with Dr. F. E. Hoare of the Department of Physics on the determination of the specific heat of high polymers down to liquid hydrogen temperature. Other studies include rapid reaction kinetics in the liquid phase (Dr. E. F. Caldin) and thermochemistry of mercury compounds and other substances (Dr. A. S. Carson).

Dr. A. D. Walsh, Reader in Physical Chemistry, continues his well-known researches in the fields of ultra-violet spectroscopy and combustion problems.



### Structural Effects in the Polymerization of Substituted Olefins

In continuing their systematic investigations on the kinetics and thermodynamics of the interpolymerization of olefins with sulfur dioxide, Prof. F. S. Dainton and collaborators have obtained strong evidence that the polymers formed from cis and trans butene-2 respectively are not identical. The ceiling temperatures are  $35.7^{\circ}$  and  $32.5^{\circ}\text{C}$  under the conditions employed and it was shown that above about  $25^{\circ}\text{C}$  both reactions are accompanied by isomerization, the rate of which increases rapidly with temperature. Above the ceiling temperature for polymerization the isomerization occurs rapidly, but no isomerization takes place if sulfur dioxide is absent or, with it present, the system is not illuminated (cf. Nature 172, 804 (1953)).

It was recently observed that the heats of these polymerization reactions are about -19.2 and -20.1 Kcal/mole for the cis and trans butene-2 respectively. Since the heats of solution of the two isomers are identical within experimental error, there appears to be a difference of over 2 Kcal in the heat content of the resulting polymer per monomer unit (the unit consists of  $[\text{CHR} - \text{CHR} - \text{SO}_2]$ ). Thus it seems very probable that despite the fact that isomerization was shown to occur rapidly under the conditions of these experiments, the polymers formed from the two isomeric monomers are not identical. Detailed stereochemical considerations suggested the possibility of frozen-in rotational isomers. No difference was detected in their infra-red spectra, however, and their study is made generally difficult by their very low solubility in all ordinary solvents.

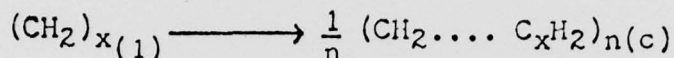
In a closely related study the heat of interpolymerization with sulfur dioxide of a series of substituted olefins was investigated; the effect of size and number of substituents largely agrees with expectations. The heat of polymerization decreases slightly in the series propylene, 1-butene, 1-pentene; the decrease is somewhat larger in the series 1-butene, 2-butene, isobutene, indicating increasing steric hindrance.

The calorimetric technique used is a convenient development of the ice-calorimeter using diphenyl ether as the working fluid. The volume change of the olefin solution is observed simultaneously and is a measure of the degree of polymerization. A trace of butadiene is used as inhibitor in these photochemically initiated reactions to provide a convenient starting time for the calorimetric measurements.

### Ring-Chain Polymerizations

In collaboration with Dr. P. A. Small (I.C.I. Plastics Division), Prof. Dainton has carried out a theoretical analysis of the processes involved in the formation of long chain polymers from ring compounds; the conclusions generally agree with experimental knowledge and are stimulating new investigations.

Writing the process generally as



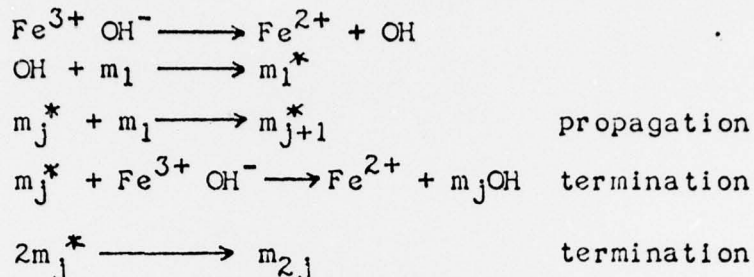
where (1) stands for liquid and (c) indicates glassy or crystalline, it is found that the most important entropy change in the process is the "structural" one comprising changes in shape, moments of inertia and symmetry. The thermodynamic results indicate that in the case of cycloparaffins (of which ethylene can be considered as the first member of the series) the first three should polymerize to long chains readily, while the subsequent members probably undergo small positive or negative free energy changes in the process. Detailed results indicate that these ring-chain polymerizations associated with positive heats and entropies of polymerization, should show a "floor" temperature, a reverse analog of the ceiling temperature suggested by Dainton et al several years ago. A possible well-known example of such a temperature, below which polymerization will not occur may be that in liquid sulfur which undergoes extreme changes at 160°C associated with S<sub>8</sub> rings forming very long polymer chains (cf. also Trans. Farad. Soc., 49, 441 (1953)).

### Ferric Ions as Terminating Agents in Polymerization

The polymerization of acrylamide was investigated under a variety of conditions and it was found that ferric ions can be important as terminating agents; the solubility of the polymer in water makes this a convenient system to study. The kinetic observations for γ- and x-ray induced polymerization and for the photochemically induced polymerization are in good agreement and thus in this system the hypothesis of non-uniform radical distribution when ionizing radiations are used for initiation is certainly not tenable (cf. General Discussion of the Faraday Society No. 12, pp. 212, 273, 277 (1952)).

In the photochemical initiation the well-known ferric-ferrous system was used; the essential independence of the rate observed from the  $[\text{Fe}^{3+} \cdot \text{OH}^-]$  concentration indicates that this species is also a terminating agent. The following kinetic

scheme is proposed:



A dilatometric study of the photochemically induced polymerization of acrylonitrile provides further evidence of the chain terminating ability of ferric ions. In the presence of fluoride complexing ions the rate does not level off but continues at its high initial value.

#### STUDIES OF HEARING .

Dr. Hans Engström, Department of Histology, Caroline Institute, Stockholm, has completed a number of studies using electron microscopy to examine sensory and neural elements of the normal cochlea of the guinea-pig. He has described many new details of the structure of hair-cells, supporting cells, and the endings of nerve fibers around the sensory cells. He is now turning his attention to investigation of changes which take place in cochleas damaged by disease, by drugs, or by acoustic trauma.

Dr. Gunnar Hammer, Department of Otolaryngology, University of Göteborg, Sweden, is also studying the finer structures of the cochlea through the use of x-ray and ultraviolet microscopy. In experiments which are only in a preliminary stage, he has obtained results which indicate that one of the first signs of damage in mild acoustic trauma may be changes in nerve cells of the spiral cochlear ganglion.

In the Department of Otolaryngology, Rikshospital, Oslo, under the direction of Prof. O. Opheim a new laboratory for research in psycho-acoustics has been established. Dr. Gordon Flottorp has primary responsibility for directing the research activities of the laboratory. At the present time work is underway on design of special auditory tests to be used in the diagnosis of Meniere's disease.



#### REDOX PUMP FOR ION MOVEMENT

Prof. E. J. Conway of the Department of Biochemistry, University College, Dublin, is studying the movement of inorganic ions ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Cl}^-$ ) into and out of frog sartorius muscle fibers. The movement of the ions is followed both by direct chemical analysis and by using radioactive tracers. Measurements are also being made (under comparable conditions) of the resting potential of the muscle fibers using the technique of Ling and Gerard. The data should provide values for the parameters of equations developed by Prof. Conway to describe the kinetics and energetics of ion movements across cell barriers (cf. E. J. Conway, A Redox Pump for the Biological Performance of Osmotic Work and its Relation to the Kinetics of Free Ion Diffusion Across Membranes, International Review of Cytology 11, 419-445 (1953)). Prof. Conway proposes that electron transfers (from substrates to oxygen) can be used to move ions without the necessity for energy capture in, for example, high energy phosphate bonds. If this hypothesis can be established there would be another mechanism available for energy capture and work performance. The accountable free energy efficiency of cells would thereby be increased.

#### PERSONAL NEWS ITEM

Dr. R. F. Naunton is resigning his position with the Wernher Research Unit of Deafness, King's College Hospital, London, to accept an appointment as Research Associate in the Division of Otolaryngology, Department of Surgery, University of Chicago. Dr. Naunton will assume his new position in September.

#### TECHNICAL REPORTS OF ONRL

The following reports have been forwarded to ONR, Washington. Copies may be obtained by addressing requests to the Commanding Officer, Office of Naval Research Branch Office, Navy No. 100, c/o Fleet Post Office, New York, N. Y.

- ONRL-50-54 "Organic Chemistry at the University of Amsterdam" by J. C. Sheehan
- ONRL-54-54 "Research in Cosmic Rays and Nuclear Physics in Central and Southern Italy" by J. R. Richardson
- ONRL-55-54 "Biological Applications of Interference Microscopy" by J. O. Hutchens



ONRL-60-54 "Ferranti Linear Programming Conference" by  
W. D. Hayes

ONRL-62-54 "Aerodynamic Research in Sweden" by W. D. Hayes

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